

this time no more rain fell until early in September. This long-continued drought reduced the streams of water to mere rills, and many springs and wells heretofore unfailling became dry, or nearly so. The grass crop entirely failed, and through several counties the pasture grounds in places were so dry that in walking across them the dust would rise under the feet, as in the highways. So dry was the grass in meadows that fires, when accidentally kindled, would run over them as over a stubble field, and great caution was required to prevent damage from them. The crop of oats and corn was nearly destroyed. Many fields of wheat so perished that no attempt was made to harvest them. Scions set in the nursery dried up for lack of sap in the stocks, and many of the forest trees withered, and all shed their leaves much earlier than usual. The health of the inhabitants was not materially affected, although much sickness was anticipated. Grasshoppers were multiplied exceedingly in many places, and destroyed every green thing that the drought had spared, even to the thistles and elder tops by the roadside.

The late frosts and cold drying winds of the spring months cut off nearly all the fruit, and what few apples remained were defective at the core and decayed soon after being gathered in the fall. Many of the farmers sowed fields of turnips in August and September, hoping to raise winter food for their cattle, but the seed generally failed to vegetate for lack of moisture. So great was the scarcity of food for the domestic animals that early in autumn large droves of cattle were sent into the valleys of the Sciota, where the crops were more abundant, to pass the winter, while others were sent eastward into the borders of Pennsylvania. This region of country abounds in grasses, and one of the staple commodities is the produce of the dairy. Many stocks of dairy cows were broken up and dispersed, selling for only four or five dollars a head, as the cost of wintering would be more than their worth in the spring. Such great losses and suffering from the effects of drought have not been experienced in that portion of Ohio for many years, if at all since the settlement of the country. As the lands become more completely cleared of the forest trees dry summers will doubtless be more frequent. In a region so near a large body of water we should expect more rain than in one at a distance. The sky in that district is, nevertheless, much oftener covered with clouds than in the southern portion of the State, where rains are more abundant; but the dividing ridge or height of land between Lake Erie and the waters of the Ohio lacks a range of high hills to attract moisture from the clouds and cause it to descend in showers of rain.

[NOTE.—The above prediction that the frequency of dry summers will doubtless increase "as the lands become more completely cleared" has not as yet been verified, although the forests have been greatly reduced and the rainfall records greatly multiplied. Undoubtedly the dryness of the surface soil has been increased by sunshine and winds and plowing and draining, but the cloudiness and rainfall and snow, which are the true meteorological phenomena, do not seem to have been appreciably affected by the increase of the population and the cultivation of the land. Our knowledge of atmospheric motions attending rain leads us to conclude that extensive areas of cloudless sky and no rain must be due to the presence of slowly-descending air; the dryness and heat observed in the lower atmosphere are the outcome of three influences, viz: the compression of descending air, the nocturnal radiation and the daily insolation. The evaporation from soils and plants, oceans and lakes, is in general carried far away before it falls as rain. If it be true, as above stated, that in a region so near Lake Erie as is the State of Ohio "we should expect more rain," still it is equally true that the rainfall of Ohio is not appreciably increased by the presence of Lake Erie except along the immediate coast, and we must look to some other influence as the origin and cause of its rainfall. Evaporation adds moisture to the air, but what brings it down? Experience shows that rain occurs in three classes of localities: (1) Where the winds push up over highlands; (2) where cool air underruns and lifts up warmer air; (3) where overheated surface air rises to let the surrounding heavier air take its place. All three of these are summed up in the one expression "rain falls from masses of air that have been raised high enough to cool, by expansion, decidedly below the dew-point." How far this cooling must go or what other factors come into play is still a subject for further discussion, but it seems certain that the primary essential is the ascension of a large mass of moist air, and when this feature is absent there will be no considerable rain.]

A REGION OF HEAVY RAINFALL.

The following is taken from the monthly meteorological report of the North Carolina State Weather Service for August, 1895, p. 135.

Mr. B. C. Hawkins, voluntary observer at Horse Cove, Macon County, in western North Carolina (near the boundary between North Carolina and Georgia, N. 35°, W. 83° 10'), writes:

Owing to the system of mountain and valley winds on the southeast slope of the mountains the tendency at this station is for northeast winds at night and southeast winds in the daytime. Very often the winds are northeast at sunrise, but by 9 a. m. are fresh from the southeast. Sometimes the night winds are from the northwest or north, the day winds from the south or southwest, but the northeast night and southeast day winds are the most marked. These winds are broken up by the passage of highs and lows of marked intensity. I believe this system extends over many adjacent counties, and that these winds are one cause of the local heavy precipitation which occurs in northern Georgia, northwestern South Carolina, and the western portion of North Carolina. Would not such winds have a tendency to force large volumes of moist air up the Blue Ridge? When a cyclone appears in the west the natural direction of the wind here would be southeast, but the diurnal winds would increase the amount of air in motion. * * * Heat action on the slopes of the mountains would probably rarely be sufficient to cause rain independently, but would increase the amount in most cases when cyclonic action comes into play. Professor Harrington in "The Rainfall of the United States," attributes the excessive rainfall of the southern Blue Ridge entirely to the contact of storms, especially Gulf storms. * * * I believe, however, that these mountain and valley winds increase the rainfall greatly. They may have something to do with the severe cloud bursts which are common here, and of which an unusually large number occurred in June, 1876.

THE CALCULATION OF NORMAL VALUES.

It is important to decide whether a normal value of any meteorological datum is always best obtained by simply taking the mean of all observed values. Our idea of a normal implies, first, that it is the average of a great number, and, secondly, that it contains within itself nothing abnormal—that is to say, that abnormal events have so counteracted each other as not to injuriously affect the average of many values. If, for instance, we have a number of total monthly rainfalls for August ranging between zero and two inches, and if we know that, as far as experience goes, there is no reason to think any of these to be very abnormal, then the average of all will properly be used as the approximate normal for that month and place; but if among these there occurs one month with a cloud-burst (as when 24 inches of rain fell at Palmetto, Nev., in August, 1890), then this abnormal value will so affect the average of all that the latter will not be a proper normal. Such an abnormal value should be included with the others in the general average only when the series is so long—say 100 or 500 values—that the error introduced by counting it in shall become insignificant because divided by the large number. That is to say, if a cloud-burst may be expected but once in a hundred years at the station, then the average of a century of records including one cloud-burst would be a proper normal, but the average of ten years, including the cloud-burst, would not be a proper normal. In the latter case we must reject the cloud-burst and take the average of nine years as an approximate normal and wait for the century of records to accumulate.

There is a general proposition in the mathematical laws of chance, according to which the most probable mean value is determined only after rejecting observations whose abnormality is such that the probable error of the resulting mean is increased by using them. The rule according to which we may judge whether an observation should be rejected for such abnormality is fully explained in Chauvenet's treatise on "The Method of Least Squares," published as an appendix in the second volume of his "Spherical Astronomy." The application of the laws of chance or probability to meteorologi-

cal problems is well set forth in Meyer's "Anleitung," but the criterion for the rejection of abnormal observations is not mentioned by him. There are perhaps but few opportunities for its application in meteorology, but its propriety seems very evident in case of such excessive rains as at Cherrapoonjee, India, and in our American "cloud-bursts." The further study of this subject is of interest.

PROTECTION FROM FROST.

In a recent number of the *WEATHER REVIEW* (November, 1894, page 463) some suggestions are given as to methods of protecting tender vegetation from injury by severe frost. In that article the sprinkling of the plant and the ground with water is especially mentioned as a preventive. On this subject Prof. R. C. Kedzie, of the Michigan State Agricultural College, at Lansing (as quoted in the August Bulletin of the Michigan State Weather Service), says:

The great regulator of temperature is water. Water in becoming warmed takes up a large amount of heat and gives out the same amount of heat in cooling. Evaporation is a powerful cooling process and condensation of water vapor is an equally powerful heating process. The vapor of water in the atmosphere may control excessive changes of temperature in two ways:

1. By condensing into water it liberates enough heat to raise through one degree the temperature of a thousand times the amount of water condensed, and, hence, powerfully arrests the fall of temperature by giving out heat. In this way the beneficent dew becomes a warming-pan for our chilling fields.

2. The vapor of water in the air (and the clouds also) prevents the escape of heat by radiation from the soil and consequent cooling of the ground during the night. But for the vapor of water in the air we should have a frost every night in the year. The removal for a single summer night of the aqueous vapor which covers England, would be attended by the destruction of every plant which a freezing temperature could kill.—Tyndal on Heat, p. 405.

If the farmer is forewarned of the approach of a still frost he may do something to avert the calamity. The conservative influence of watery vapor is the most hopeful means of protection, and sometimes trivial causes of this class will produce surprising results. The old plan of a tub of water under the fruit tree, and a rope reaching from the tub into the branches, may serve a useful purpose. The evaporation from the water in the tub and of the water carried up by capillary action in the rope may spread the protecting folds of the water blanket over the tree. Such appliances, while of some use for a small garden, would be futile for a farm.

If the hoed crops of the farm are cultivated with reference to securing a constant supply of moisture in the upper soil, to draw by capillary action of the soil upon the reservoir of water in the subsoil, and at the same time to keep the surface soil in such condition as to prevent the too rapid dissipation of soil moisture, the fields may be saved from frost by a covering as impalpable as air but as effectual as eider down. Here is a conservatism of highest importance for both farmer and fruit grower. On the night of September 16, 1868, the Indian corn in Michigan was almost entirely killed by frost, only a few fields along the banks of rivers or the borders of lakes being spared. In these fields the corn stalks the next morning were dripping with dew. The evaporation from river or lake during this dry time (only one-eighth inch of rain in two weeks) had moistened the air in the vicinity and staved off the frost. Away from bodies of water the air was very dry and the dew point low. At the Agricultural College the temperature in the open air at 2 p. m., September 16, was 54°, the wet bulb marked 44°, and the temperature of dew-point was 31°. During the night the temperature sank to 24°, and a black frost was the result. If the air over the whole State had been as moist as it was along those rivers and lakes, a heavy dew would have fallen everywhere and the corn crop would have been saved.

This immunity from frost afforded by a moist atmosphere is a matter of great importance. I once read in a newspaper of the experience of a farmer who feared a frost on his growing corn, and who cultivated the field, stirring up a moister soil, and thus promoting evaporation, with this result, a heavy dew and a rescued crop, while neighboring fields of corn were cut by frost.

Ten years ago some beautiful beds of coleus were near my house. Early in October there were threatenings of frost. Every evening the beds were thoroughly wet down with cold water, and the tender coleus plants escaped frost while other plants near by were killed. At this time I found my neighbor one evening putting blankets over his grapevine to save the fruit from frost. I advised him to take away his woolen blankets, and put on the water blanket by a thorough drenching with water. This was done and the grapes saved.

This use of water to guard tender plants from frost has frequently been tried at the college, and generally with good results. Strawber-

ries and grapes in blossom may be saved in this way and with little trouble, if a good supply of water and a sprinkling hose are available. The quick-witted farmer or gardener will find many ways of using water for this purpose. With irrigation we might defy frost during the growing season.

When water is not available for such purpose advantage may be taken of fire to ward off frosts; not by the hope of warming the body of air over a field, but by forming a canopy of smoke over the field to prevent the escape of heat by radiation from the ground. In France the vineyards at the time of blossoming of the grape vines are often preserved in this way. Any material that will form a dense smoke, like coal tar, is preferred for this purpose. A smudge is better than a bright fire because it makes more smoke.

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The use of water in case of frost may be found beneficial even after the frost has occurred. Several cases are known where, after the severe frosts which occurred in May, 1895, several acres of grapes were saved by a thorough drenching with water early in the morning after they had been quite severely bitten by frost.

The following paragraph from the Orange Judd Farmer, August 31, 1895, is worth repeating in this connection:

Protection against frosts is a vital matter to fruit growers and truckers, whose season's labor and investment may be wiped out by a single destructive frost. The more valuable the crop and the greater the risk of frost the more effort and expense may be safely put into means of protecting against frosts. A famous California orange grove is equipped with a system of iron pipes, through which water is conducted to nozzles at frequent intervals, the idea being that the spray will ward off light frosts. Barrels of tar and rubbish in different parts of the orchard are available for making a smudge of smoke, which is the most practicable means yet devised. In the case of a freeze such as visited California two years ago and Florida last winter, or a real hard frost in other sections, neither of these methods is of much avail. Smoke is good against all light frosts and is easily obtained. Straw manure, leaves, rubbish, etc., should be piled in the lowest places and about the sides of the field and covered with hay caps or ducking (previously painted with two coats of linseed oil and dried), so as to be always dry. Have a barrel of kerosene oil handy, some cans and torches. When the frosts threaten, set a night watch to inspect thermometers placed on stakes in various parts of the field, especially in the most exposed places. If the mercury drops to 35° by 1 or 2 a. m., it is likely to mean a frost of more or less severity before sunrise. Then call up the folks, light the torches, and let each person take torch and oil can (previously filled) and set fire to the row of rubbish heaps previously assigned him. If the wind blows the smoke away from the field, carry some rubbish over to the windward side, so that the smoke will be blown to instead of from the field. If the frost does not come, no expense worth mentioning has been incurred, as the piles can be scattered and plowed under for manure or burned, the ashes making excellent fertilizer. No prudent person thinks of leaving his buildings uninsured against fire. Certainly it is just as important to insure against frosts, so far as it can be done by such simple means as smoke coverings, or water. We wish all who have had experience in this matter would send it for publication.

Mr. E. P. Powell, a successful and brainy horticulturist in western New York, writes:

"The very best preventive against frost is not fires, but thorough spraying with water during the evening and night. When this can be done, we can overcome the danger from a fall of two or three degrees. This will often save our whole crop. This last spring I lost my grapes by a margin of not more than two degrees, but on a preceding night anticipated the frost by deluging the trellises with water. Of course bonfires may also be used. I anticipate we shall be compelled to adopt irrigation in all the Eastern States."

HOW DO RAINS AND WINDS SPREAD EPIDEMICS?

Professor Charles Mayer, as quoted from the *Tennessee Journal of Meteorology*, says:

Occasionally epidemic diseases seem to have been spread by clouds and the rain from them. The best authenticated case is that of a plague epidemic in the fifteenth century, which broke out most violently in a Swiss town immediately after a cloud, coming from an infected but distant region, discharged its rain upon that town.

[NOTE.—The relations of the weather to the spread of epidemics are still involved in great obscurity. Without going back to the fifteenth century, there was an excellent opportunity to investigate the subject in 1889-90, when the grip spread over the whole civilized world. Its progress was so regular that for a long time there was a general belief that the active germs of influenza were carried as dust in the air by the winds, or perhaps by the upper currents. This idea